



The Sun and space weather drivers

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The Sun and drivers of SW_x

- In this class we drill deeper into the physics of:
 - Sun.
 - Key processes driving solar activity.
- Some relevant iSWA product examples.

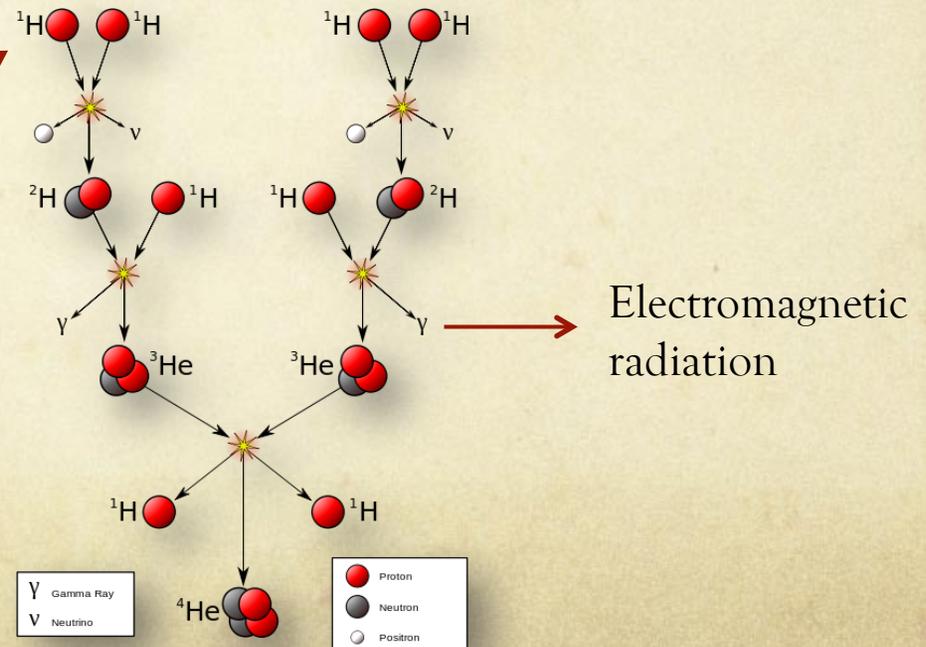


The Sun and drivers of SWx

- We already learned that the Sun is the ultimate driver of space weather.
- (primarily) *Proton-proton fusion* process operating in the solar core fuels everything.

150 g/cm³ hydrogen at
15 million Kelvin

Proton-proton
fusion chain (credit:
Wikipedia)

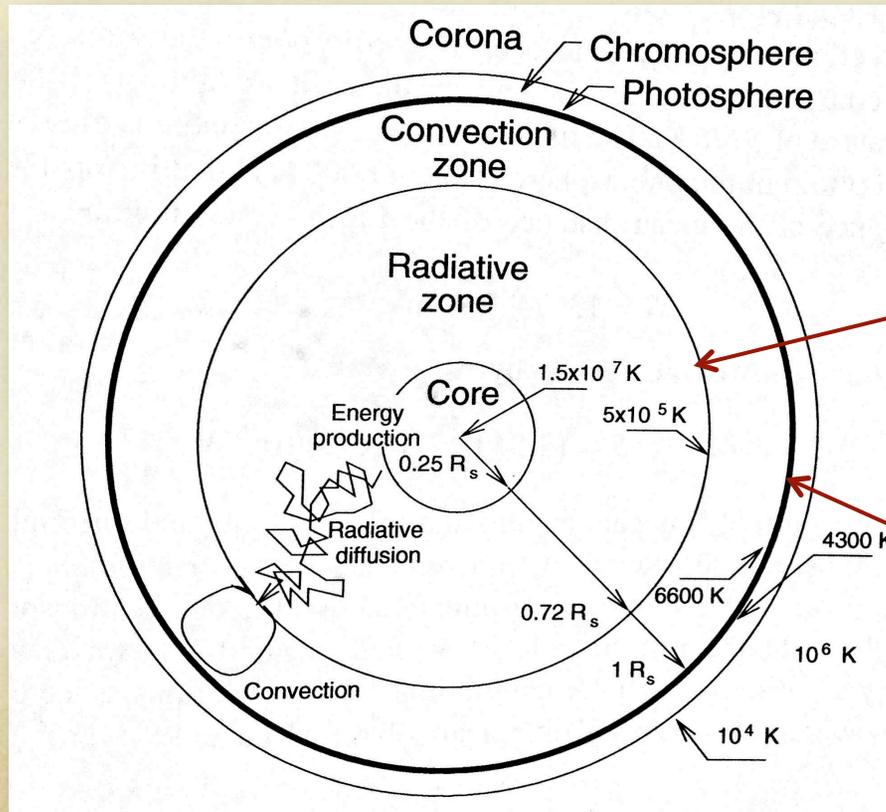


Electromagnetic
radiation



The Sun and drivers of SWx

- Generated energy transported through a variety of layers.



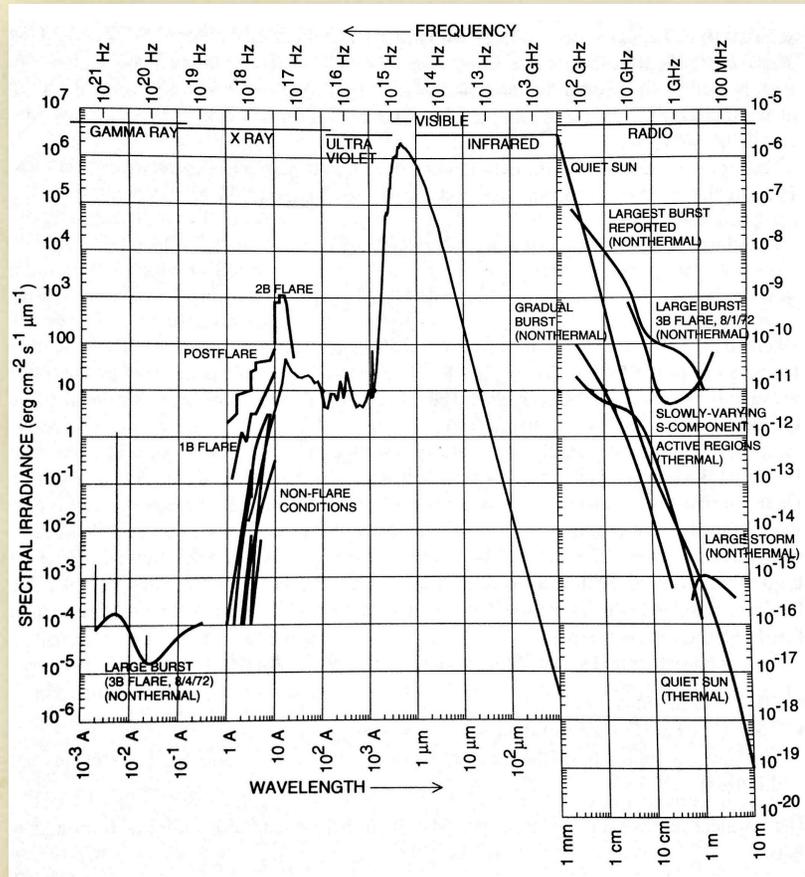
The structure of the Sun
(credit: H. Koskinen, 2011)

Most efficient means of energy transport turns into turbulent convection

Black body radiation at 5778 K



The Sun and drivers of SWx



Solar spectrum from gamma rays to radio waves.

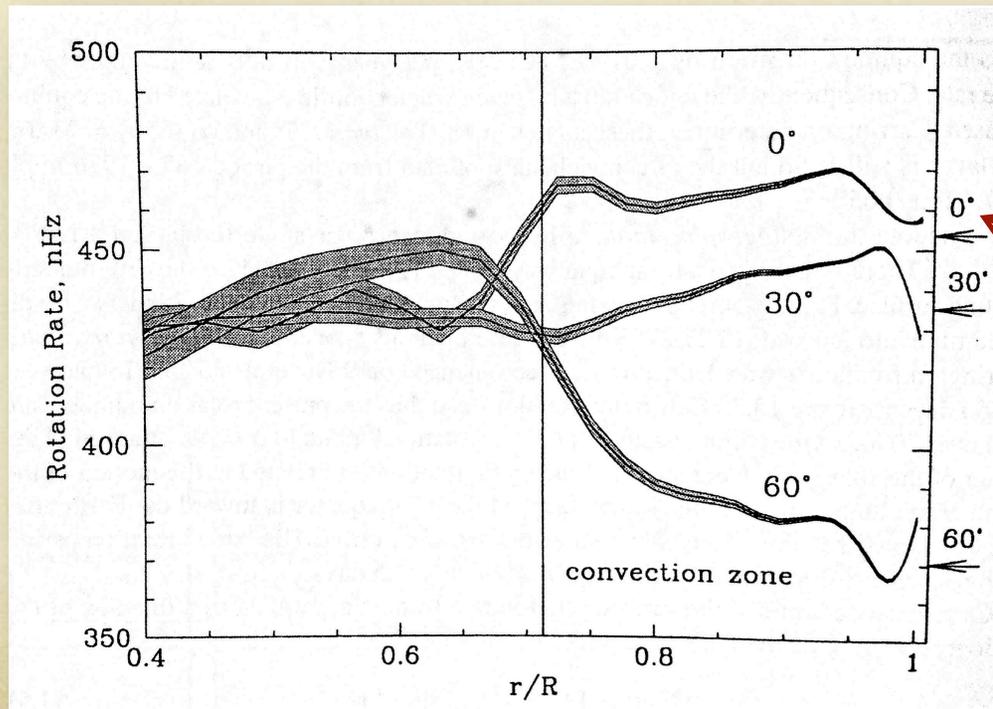
Credit: Aschwanden (2004)

Total solar irradiance or solar “constant” varying at 1 AU between about 1361 W/m² and 1362 W/m² (solar min vs max)



The Sun and drivers of SWx

- *Differential rotation* one key element of the Sun. The origins of this behavior not yet fully understood.



The internal rotation rate of the Sun

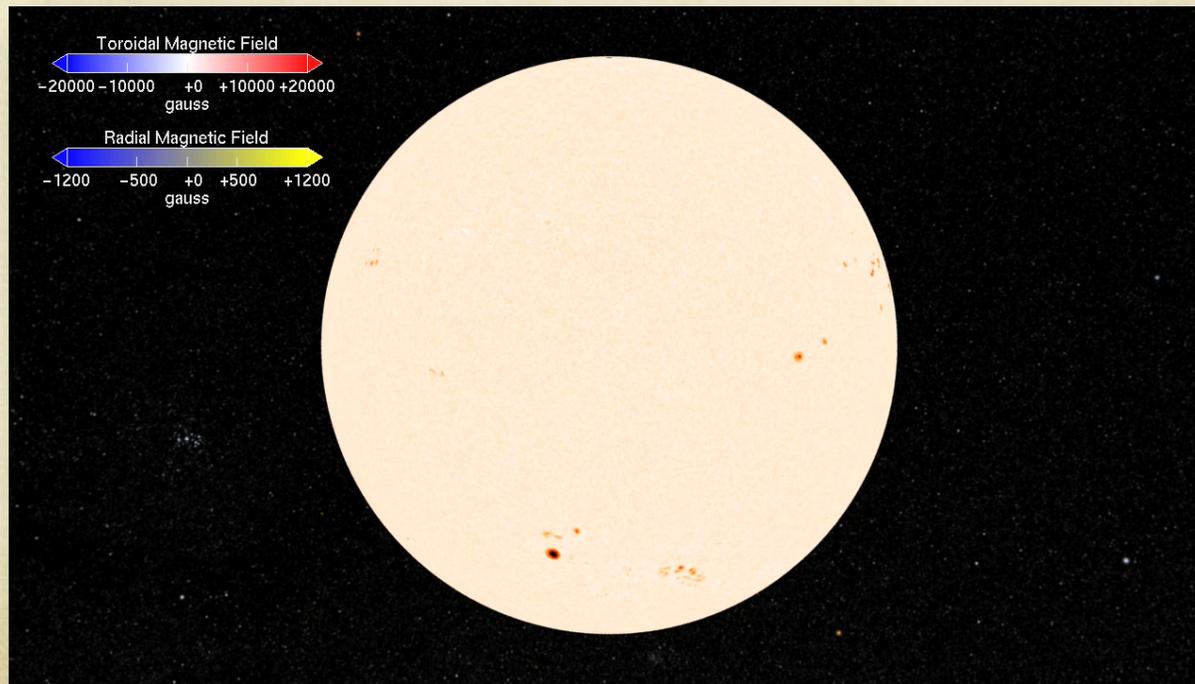
Latitude

Credit: Kosovichev et al. (1997)



The Sun and drivers of SWx

- The Sun is a magnetic beast. Turbulent flows together with differential rotation in the convection zone the key ingredients for the *solar dynamo*.



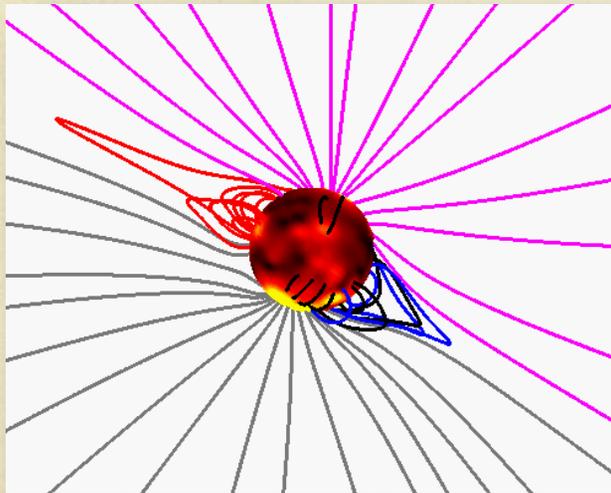
Credit: NASA GSFC SVS



The Sun and drivers of SWx

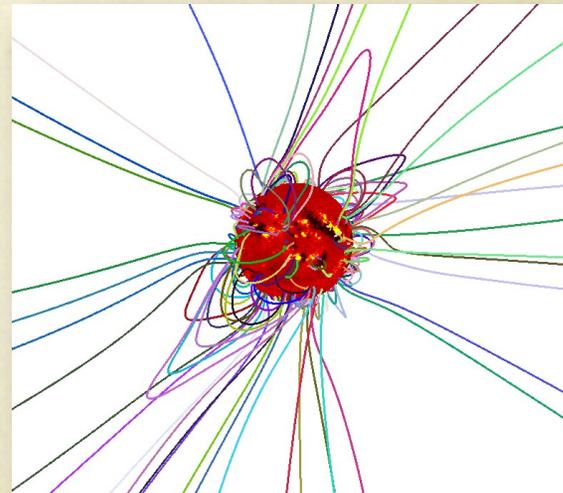
- Global structure of the solar magnetic field varies as a function of *solar cycle*.

Solar minimum



Credit: Predictive Science, Inc

Solar maximum



Credit: Predictive Science, Inc



iSWA products

- Potential Field Source Surface (PFSS) models in iSWA.



The Sun and drivers of SWx

- Sunspots that are at about 4100 K are reflection of “piercing” of the field generated in the convection zone through the photosphere.

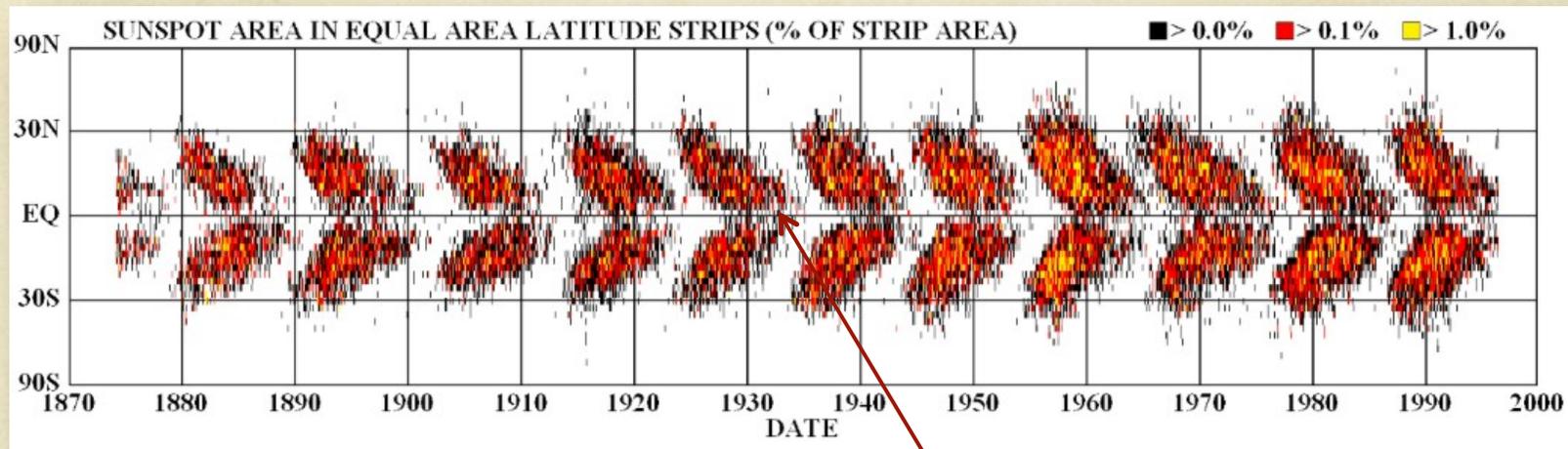


Emergence of new magnetic flux through the photosphere seen in NASA SDO white light imagery.



The Sun and drivers of SW_x

- Cyclic solar dynamo gives rise to solar cycle and the famous *butterfly diagram*.



Credit: Montana State University

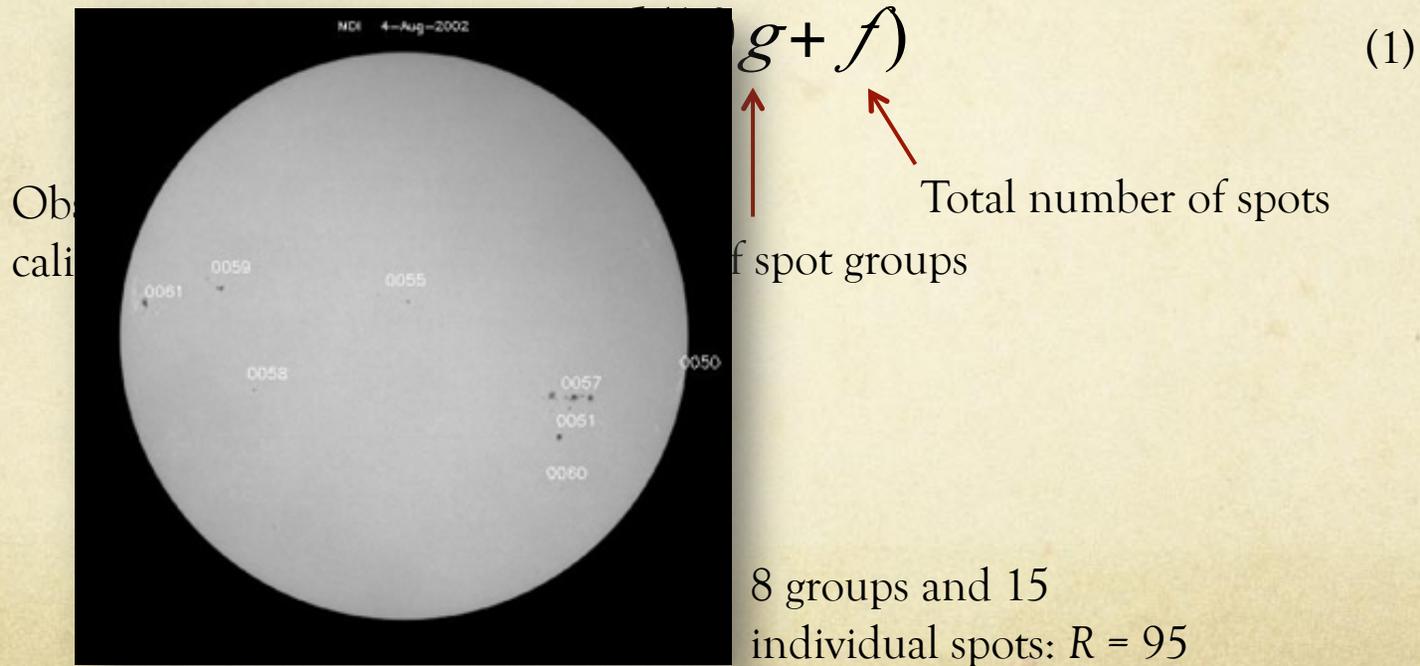
Solar magnetic field flips approx. over 11 year cycle so the full cycle is in fact approx. 22 years long

During the solar maximum activity close to the equator



The Sun and drivers of SW_x

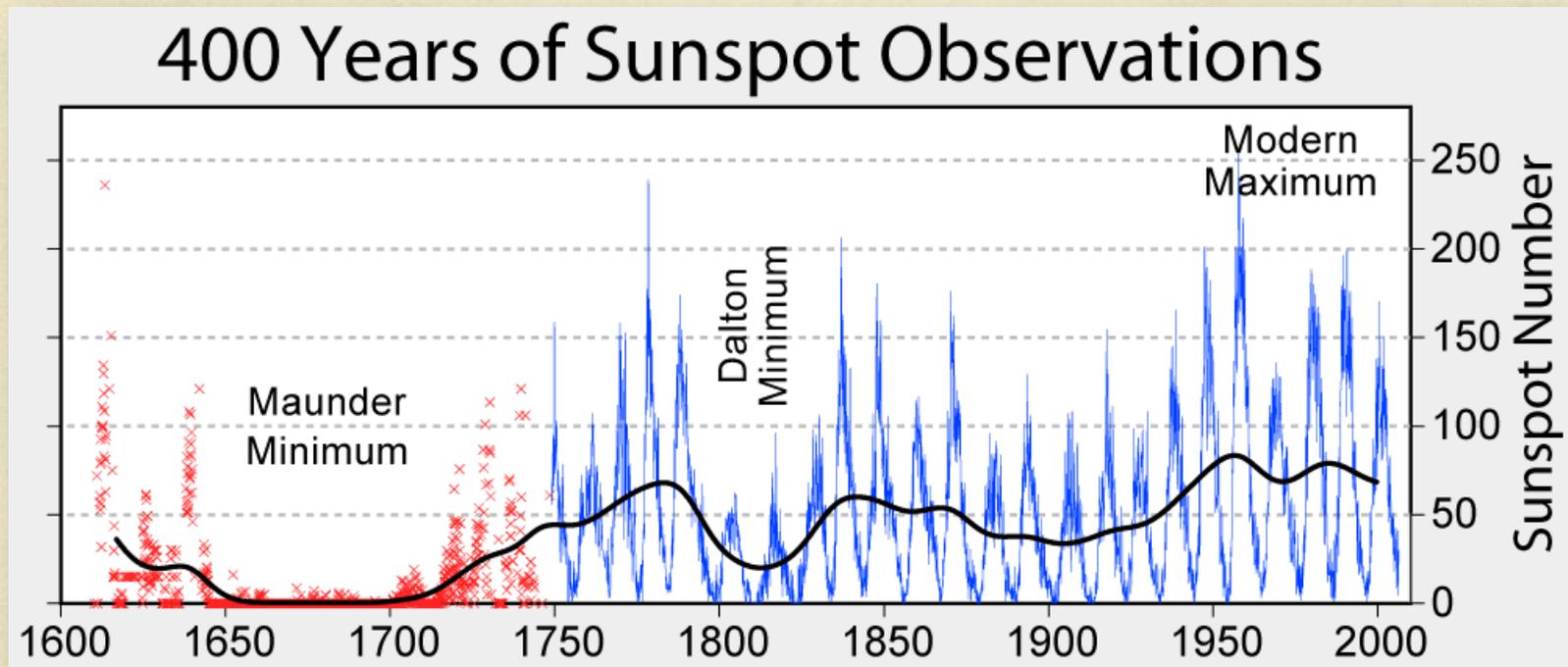
- The classic (since the 18th century) means to characterize the state of the Sun is the *relative sunspot number*:





The Sun and drivers of SWx

Credit: Wikipedia/Solar_cycle

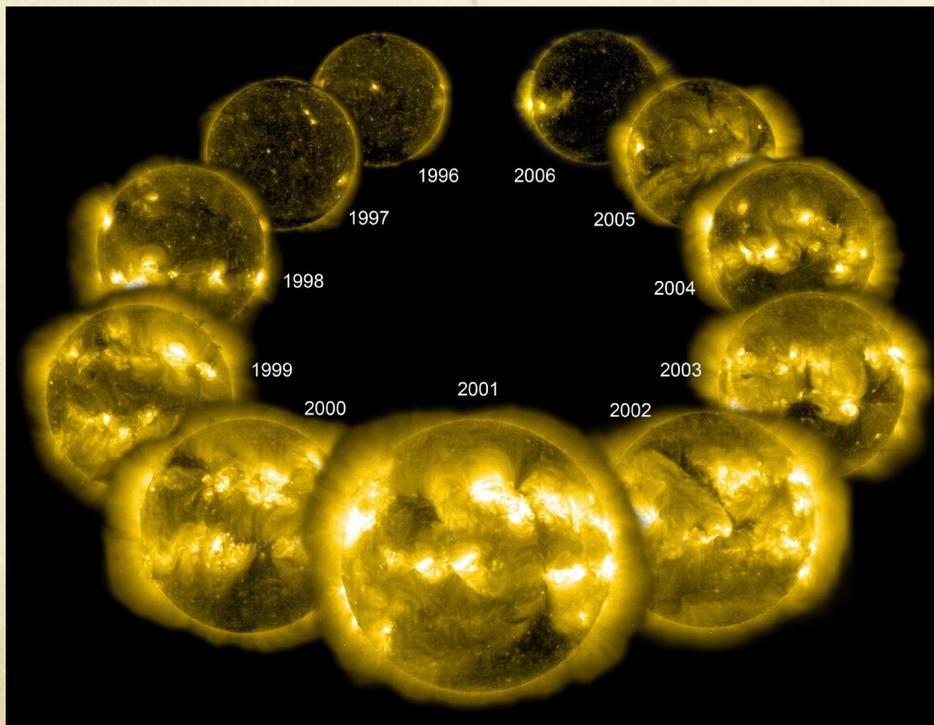


[[Solar cycle progression](#)]



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- As the global solar magnetic field structure gets more complicated also plasma configurations in the solar corona gain *complexity*.



SOHO EIT 284 Angstrom images (2 million degree plasma)

Credit: NASA/ESA



iSWA products

- Solar EUV imagery products in iSWA.



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- The build up of complexity in the corona is associated with build up of *free energy* in plasma configurations.
- The build up of magnetic free energy is often characterized in terms of *Mt Wilson sunspot magnetic classification* of the *active regions* (photosphere):

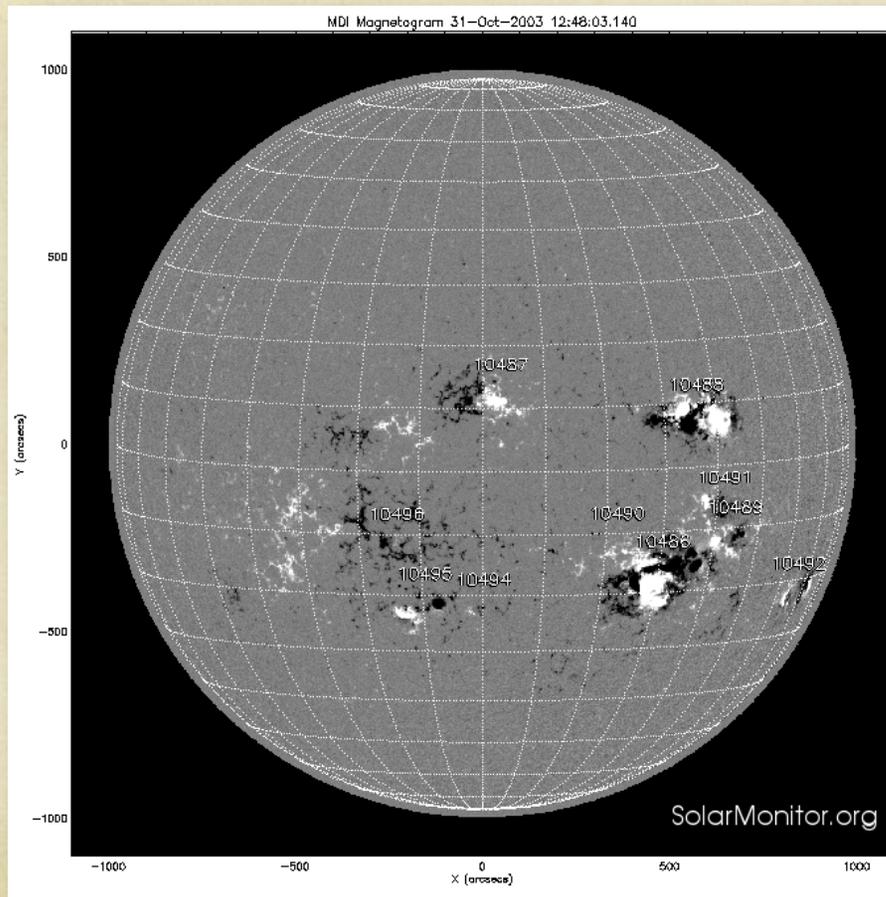
Class	Description
Alpha	A unipolar sunspot group
Beta	Sunspot groups having both bipolar magnetic fields
Gamma	Sunspot groups complicated and irregular positive and negative polar structures
Beta-gamma	Sunspots with bipolar structure, but with sufficient complexity that one continuous line can be drawn between spots of opposite polarity
Delta	Umbral separated by less than 2 degrees from penumbra with opposite polarity
Beta-delta	Groups with beta magnetic classification and one or more delta spots
Beta-gamma-delta	A beta-gamma group with one or more delta spots
Gamma-delta	A sunspot group under gamma category, but with one or more delta spots

Credit: R. Benestad
(2002)

These are explosive!



The Sun and drivers of SWx



Credit: SolarMonitor.org

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:Issued: 2003 Oct 31 0030 UTC
Prepared jointly by the U.S. Dept. of Commerce, NOAA,
Space Environment Center and the U.S. Air Force.

Joint USAF/NOAA Solar Region Summary
SRS Number 304 Issued at 0030Z on 31 Oct 2003
Report compiled from data received at SWO on 30 Oct
I. Regions with Sunspots. Locations Valid at 30/2400Z

Nmbr	Location	Lo	Area	Z	LL	NN	Mag	Type
0484	N01W95	356	0210	Dao	10	06	Beta-Gamma	
0486	S18W23	284	2600	Fkc	18	80	Beta-Gamma-Delta	
0487	N12E06	255	0280	Dko	07	23	Beta	
0488	N08W28	289	1750	Fkc	17	34	Beta-Gamma-Delta	
0489	S12W36	297	0130	Dao	06	09	Beta	
0490	S12W14	275	0010	Hrx	01	03	Alpha	
0491	S06W32	293	0120	Dso	07	10	Beta	
0492	S23W62	323	0340	Eko	11	17	Beta	
0494	S23E08	253	0010	Axx	00	01	Alpha	
0495	S22E20	241	0240	Dso	08	10	Beta	

Credit: NOAA SWPC



iSWA products

- SolarScape.



The Sun and drivers

- And from here we get to flares and CMEs...